TOPIC 3

GEOGRAPHY AND PLOTTING

To gain a greater knowledge of time theory and time conversion computations, we must have a complete understanding of the Earth, upon which we navigate and travel.

Reference points for locating objects on the Earth have been established by general agreement among maritime nations. The North and South poles are at the ends of the axis on which the Earth rotates. Imaginary lines (an infinite number of them) running through the poles and around the Earth are called *meridians.* They divide the Earth into sections. The Equator is an imaginary line around the Earth that bisects every meridian and divides the Earth in half: the Northern Hemisphere and the Southern Hemisphere. Meridians and the Equator are called *great circles* because they each divide the world into halves. Any circle drawn around the Earth so as to divide it into equal parts is called a *great circle.*

Measurement along a meridian is expressed in degrees, minutes, and seconds of arc. Each degree contains 60 minutes (´); each minute, in turn, contains 60 seconds (″).

MERIDIANS

For every degree around the Earth, there is a meridian. There are 360 of them 60´, or 3600″, apart. The starting point for numbering meridians is the one passing through the Royal Observatory at Greenwich, England.

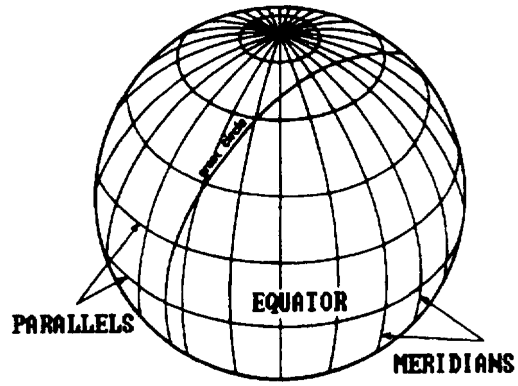

Figure 3-1.—Meridians and parallel

The Greenwich meridian is number 0. Meridians run east and west from 0 to the 180th meridian on the opposite side of the Earth. The complete circle formed by the 0 and the 180th meridians, like the Equator, divides the Earth into two exact halves: the Eastern Hemisphere and the Western Hemisphere. Every meridian runs *true* north and south.

PARALLELS

We need a second set of imaginary lines to complete our coordinate system. These lines are formed by planes that are parallel to the plane passing through the Earth at the Equator. The lines on the Earth resulting from cutting it with these parallel planes are circles called *parallels.* The starting point for numbering these parallels is the Equator. They are numbered from 0 to 90 north and south of the Equator. The system is shown in figure 3-1.

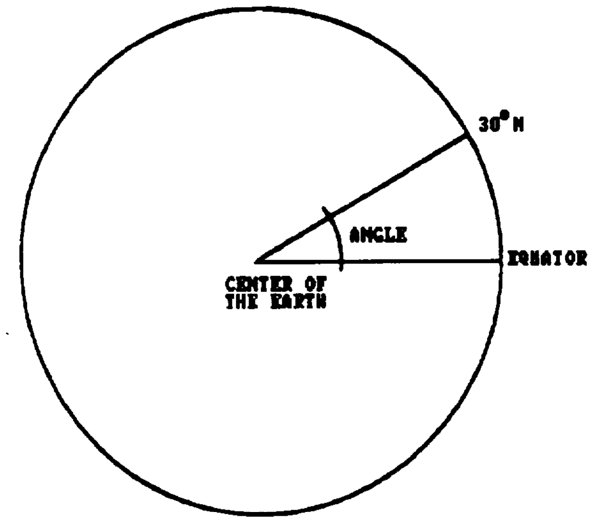

Figure 3-2.—Measuring parallels of latitude.

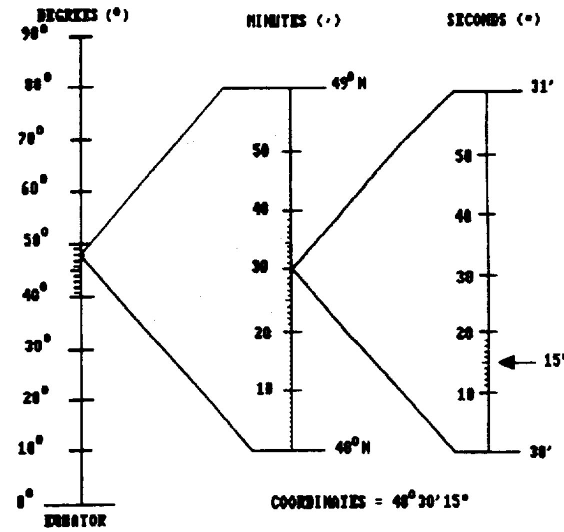

Figure 3-3.—Degrees, minutes, and seconds.

GEOGRAPHIC COORDINATES

You must use the concepts of direction and distance to locate points. Primitive man probably did this in relative terms, using aids such as the directions of the rising and setting sun, forward and backward, and left and right. He probably expressed distance in terms of travel time in relation to his own location. A universal system, however, must have some unique reference or starting point. If we designate such a point, then we can state the location of every other point in terms of direction and distance from it. The most widely accepted system of locating a point on the Earth's surface uses lines of latitude and longitude known as *geographic coordinates.* Coordinates allow us to provide an answer to the question "Where is it?"

LATITUDE

When you draw a grid on a globe, you must have a starting point. Unlike drawing a grid on a piece of paper where you can start in a corner or at the center, drawing a grid on a globe requires that you have a starting point that everybody accepts. The point of origin for latitude is the Equator. The Equator is an imaginary line, with a numerical value of 0°, running east and west around the center of the Earth.

Latitude locates a place relative to the Equator. Because the numbering of lines of latitude begins with 0 at the Equator and increases towards the poles, we must show whether the latitude of a place is north or south of the Equator.

The value of a line of latitude is determined by the angle formed by drawing a line from the Equator to the center of the Earth, and then back out to the surface of the Earth. See figure 3-2. Since the value of any angle would be constant all the way around the Earth, a line drawn on the Earth's surface connecting all the points that are formed by the angle would be parallel to the Equator. For this reason, latitude is commonly referred to as a *parallel of latitude.* Since 90° is straight up or down in relation to the Equator, the North and South poles are 90°. Therefore, you have latitude running from 0° to 89° north or south of the Equator.

Each degree is subdivided into *minutes*(′). For instance, between 48° and 49° north latitude, there are 60 minutes. If you were locating a point that was halfway between 48° and 49° north latitude, it would be at 48 degrees, 30 minutes north (48°30´N). See figure 3-3. Each minute is subdivided into *seconds* (″). For instance, between 30´ and 31´) there are 60 seconds. So if you were locating a point that was one-quarter of the way between 30´ and 31´, it would be at 48 degrees, 30 minutes, 15 seconds north (48°30´15″N). Again, see figure 3-3.

The military writes coordinates using a system called *military notation* without the symbols °, ´, or ″. This system uses 6 numbers plus a letter to indicate north or south. The coordinate 48°30´15″N would be written 483015N. When a position has less than 10° of latitude in its coordinate designation, a zero is added to the left of the degree number. In other words, latitude will have two digits. Seven degrees of latitude appears as 07 in the designation. Likewise, two digits designate minutes and seconds: for example, 030704N or 801708S.

NOTE: In geographic coordinates, always write the latitude first.

LONGITUDE

The point of origin for the vertical lines (longitude) on American and British maps is an imaginary line running from the North Pole to the South Pole through Greenwich, England. Like the Equator, it has a numerical value of 0 degrees. It is called the *Greenwich meridian* or the *prime meridian.* Many foreign maps do not use this line as the zero reference. For example, French maps use the Paris meridian, and Italian maps use the Rome meridian. Data from foreign maps must be examined to determine the prime meridian in use.

The prime meridian and the 180th meridian divide the Earth into two equal vertical parts—the Eastern Hemisphere to the right of the prime meridian and the Western Hemisphere to the left of the prime meridian.

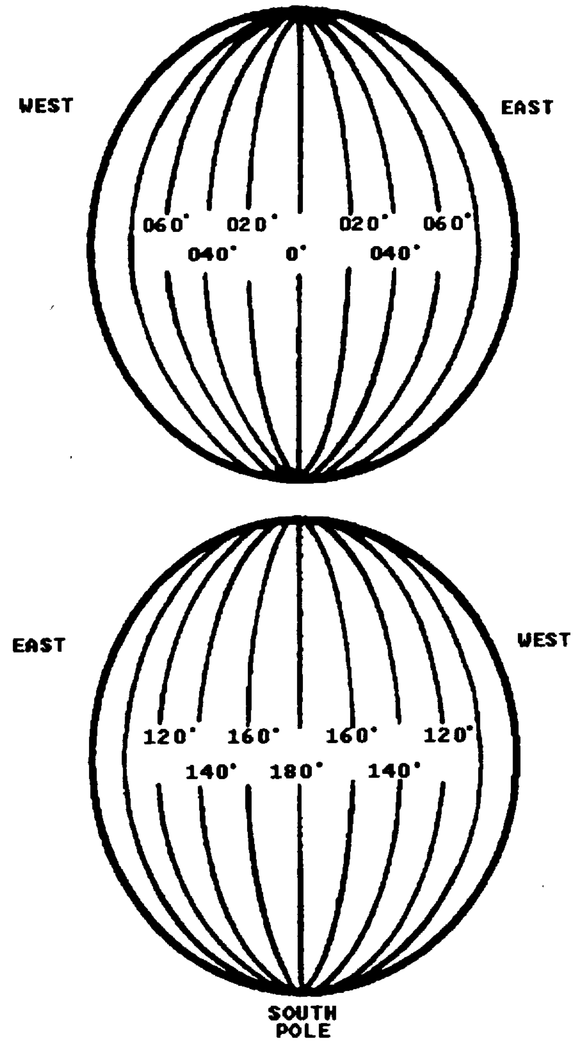

Figure 3-4.—Meridians of longitude.

All of the other lines of longitude are simply called *meridians.* See figure 3-4.

Longitude measurements are relative to the prime meridian. Because the numbering of meridians begins with 0° at the prime meridian and increases to both the east and the west, we must show whether the longitude is east or west of the prime meridian.

The value of a meridian is determined by the angle formed by drawing a line from the Equator, at the point where the prime meridian crosses it, to the center of the Earth, and then back out to another point on the Equator. See

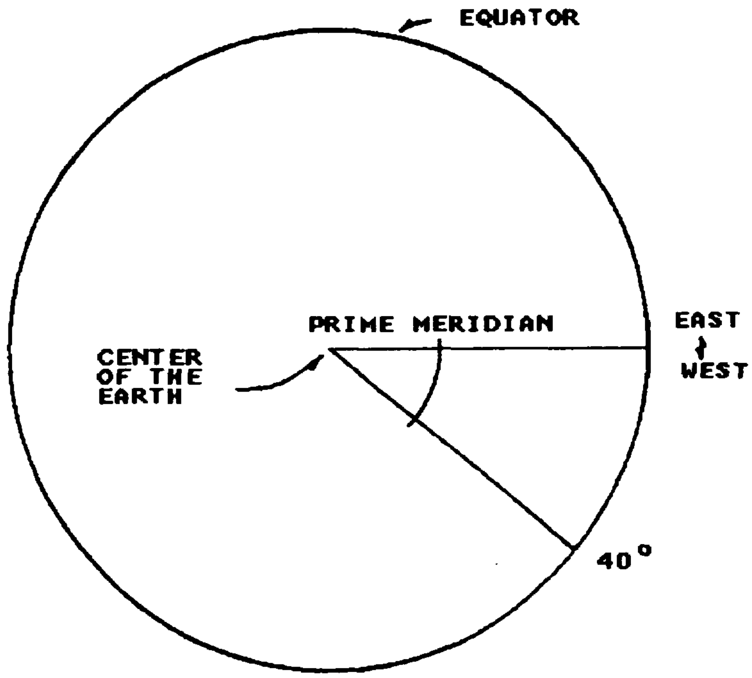

Figure 3-5.—Measuring meridians.

figure 3-5. The angle formed by the intersection of those two lines is the value assigned to that meridian. In this way, the angles are measured around the Earth in both an east and a west direction until you reach 180°. Since there are 180° on each half of the globe, you have a circle of 360°.

Each degree of longitude is subdivided into minutes and seconds in the same manner as latitude. However, remember two things about longitude:

1. West longitude is measured from right to left on a map; east longitude is measured from left to right.
2. When you write longitude in military notation, use seven numbers plus a letter to indicate east or west. When a position has less than 100° of longitude, a zero is added to the left of the degree number; less than 10°, two zeros are added. For example: 0074321W for 7 degrees, 43 minutes, 21 seconds west.

DIRECTION

We usually indicate direction from true north. We give directions in degrees, measured clockwise from true north, or 000°T. We state courses and bearings in three digits. In other words, 45 degrees is 045 (zero four five). Seldom is it necessary to consider compass direction to a value smaller than a degree, even though each degree contains 60 minutes of 60 seconds each.

A true bearing is the direction of an object from the observer, measured clockwise from true north. A relative bearing is the direction of an object measured clockwise from the ship's bow. Objects seen by lookouts are reported in terms of relative bearings by degrees. See figure 3-6.

The *reciprocal* a bearing is its opposite; that is, the point or degree on the opposite side of the compass from the bearing. For example, the reciprocal of 180° is 000°. When you obtain a bearing on an object, the bearing from the

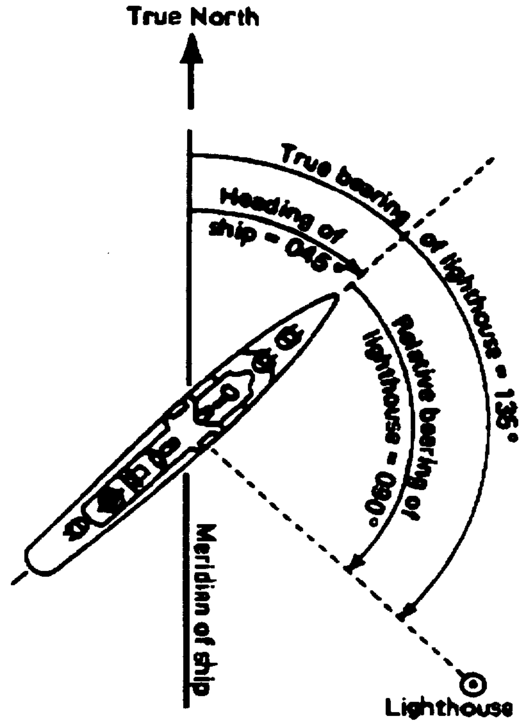

Figure 3-6.—True and relative bearings.

object to you is the reciprocal of the bearing from you to it. To fmd the reciprocal of any bearing expressed in degrees less than 150°, simply add 180° to the bearing. If the bearing is 050°, its reciprocal is 050° plus 180° or 230°. If your bearing is greater than 180°, subtract 180°.

In addition to true and relative direction measurement, there are other common references, such as measurement from the *magnetic pole* and grid reference lines on charts. However, all direction measurement systems are based on the degrees in a circle or points on a compass rose.

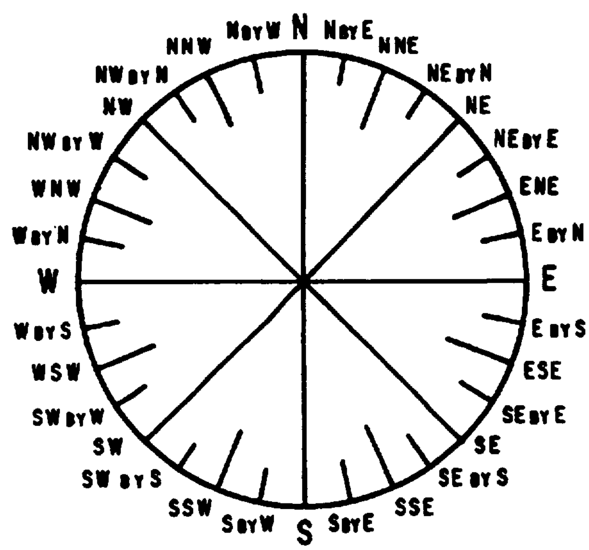

Figure 3-7.—The mariner's cardinal point system.

The Cardinal Point System

For centuries, navigators used a system of compass readings, called *compass points,* to indicate direction. An observer would use the *cardinal* points of the compass (north, south, east, and west) and intervening points between each cardinal point to indicate the direction of an object. Figure 3-7 shows the 32 relative bearings by points around a ship. The cardinal point system may be used when a high degree

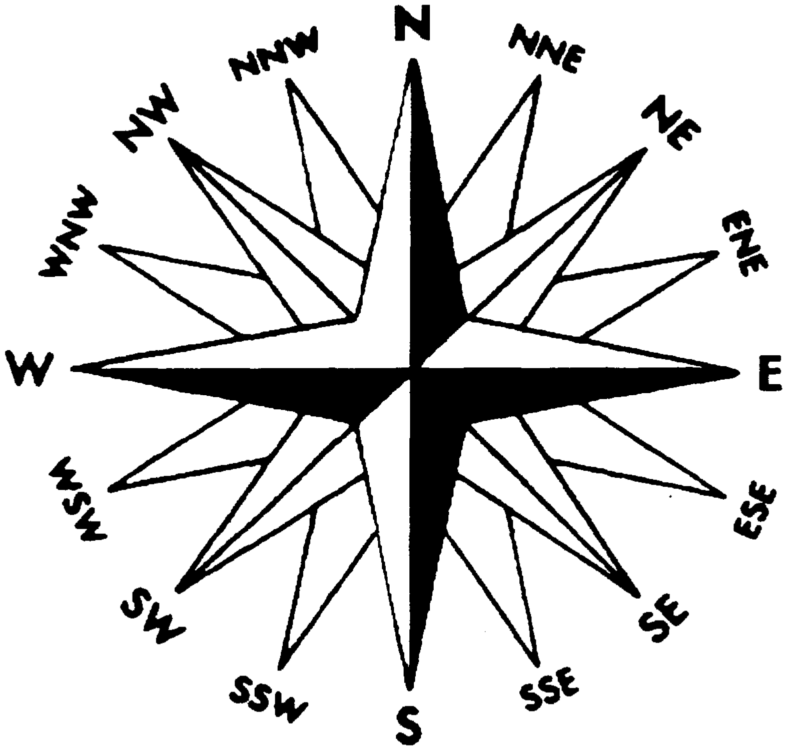

Figure 3-8.—The mariner's cardinal point system.

of accuracy is not required. Only the *rules of the road* and some harbor pilots and coastal merchant mariners still express direction in points. Figure 3-8 shows a *compass rose* with 16 points of the compass.

The Azimuth System

The azimuth system measures direction by dividing a circle into 360 equal parts, called *degrees*, and subdividing each degree into minutes and seconds. We measure direction in degrees, minutes, and seconds clockwise from north in a horizontal plane. Some marine compasses show both the cardinal point and the azimuth figures on their cards. Figure 3-9 shows a compass card with the azimuth system and eight cardinal points superimposed on it. In this figure, the subdivisions of a degree are not shown. For most navigational purposes, subdivisions of a degree are not necessary.

MAPS, CHARTS, AND PROJECTIONS

To become knowledgeable in geography and plotting, an understanding of maps, charts, and projections is extremely helpful. We will discuss these in the following paragraphs.

MAPS

A map is a graphic representation of selected features of the Earth's surface, drawn to scale. A map is a compact data base—an information storage and retrieval system—that does not require machine action. Instead, the skilled map reader retrieves information from the map.

From another viewpoint, maps are two-dimensional models of the Earth. Topographic maps are three-dimensional models that show elevation by using contour lines.

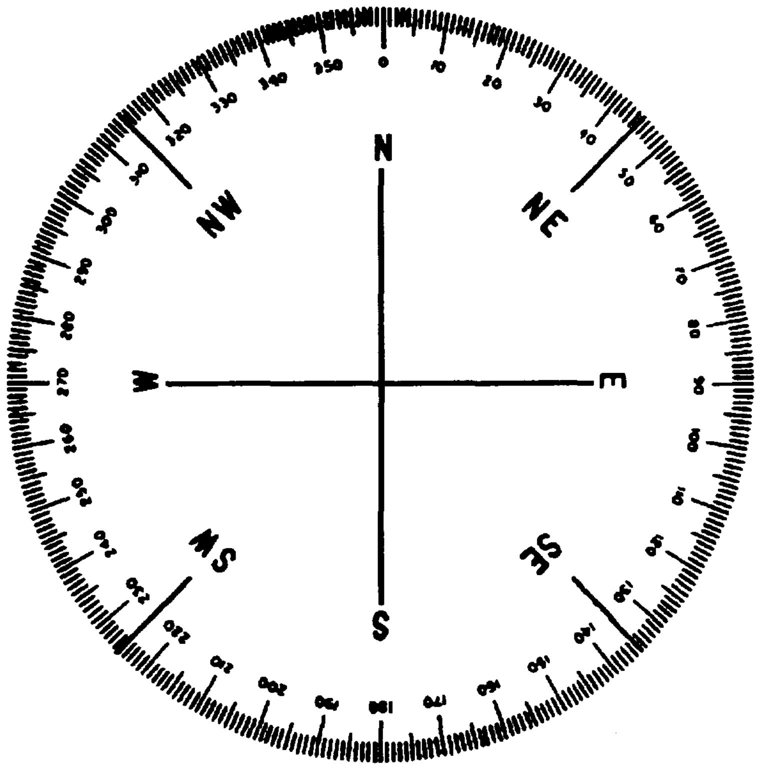

Figure 3-9.—Compass card.

The graphic representations on maps may consist of

- lines and symbols of various colors;
- drawings of landforms, called *physiographic diagrams;* or
- photographs with the addition of lines and colors to emphasize features.

CHARTS

A chart is a special-purpose map, generally designed for a form of navigation, such as air navigation. There is a difference between charts and maps. Maps show land areas, political subdivisions, and topography. A chart details water areas and has reference lines on it to allow the navigator to graphically plot information. A hydrographic chart provides information such as water depths and locations of navigational aids. An air navigation chart may show land, but it provides the air navigator with elevations as well as the locations of navigational aids.

PROJECTIONS

A projection is a method of representing a three-dimensional object on a two-dimensional surface. Cartographers (map makers) use projection techniques to build maps or charts; however, it is impossible to project a three-dimensional object upon a two-dimensional surface without distortion. The type of projection they use depends on the area to be represented and the use of the map or chart.

Distortion cannot be avoided, but it can be controlled. Map makers have created several projections to represent the Earth's surface on a plane. In any projection, they establish a network of lines corresponding to geographic coordinates. This network of lines

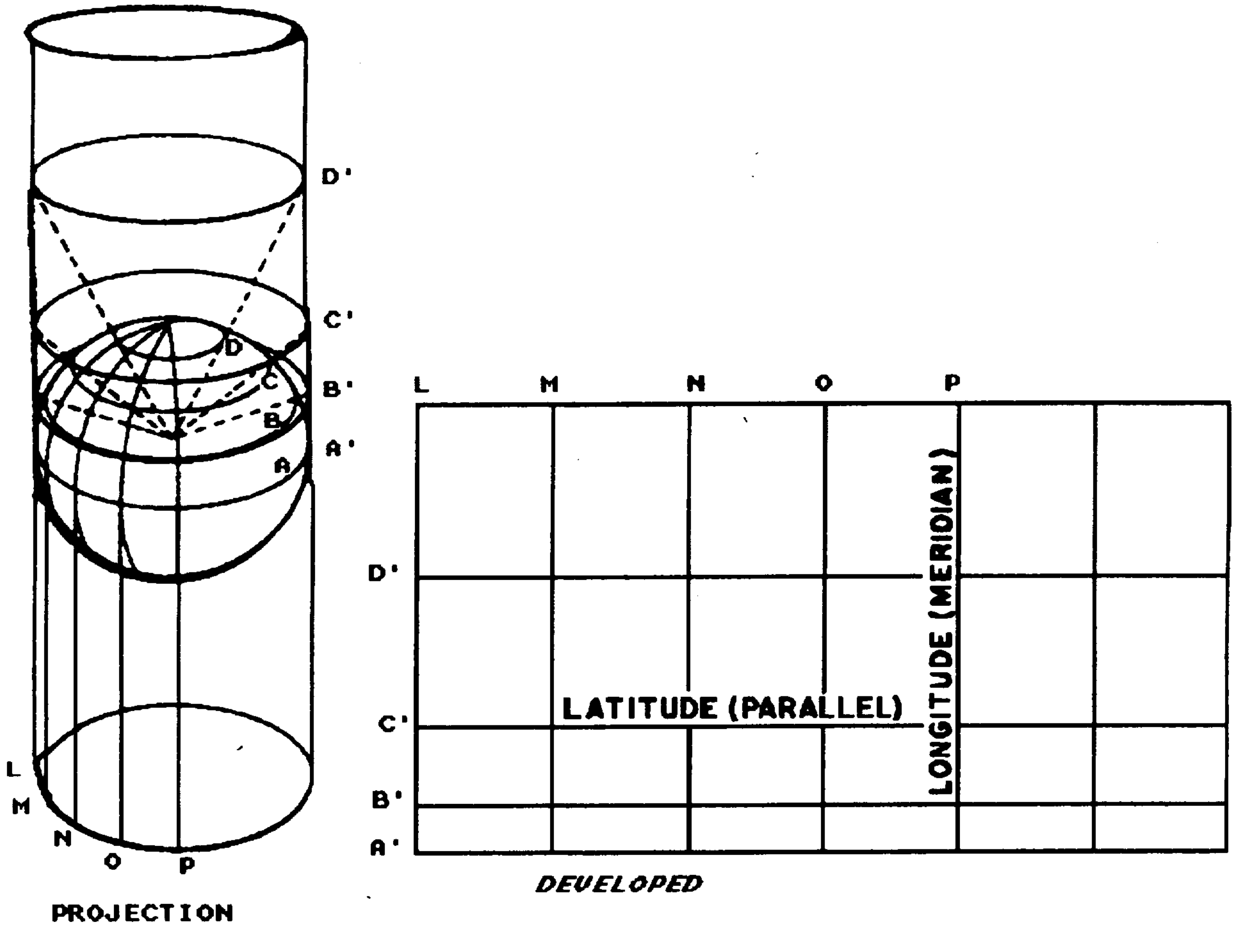

Figure 3-10.—A Mercator projection.

enables them to place each detail. To use a chart effectively, we must understand the purpose of the projection system and its good and bad features.

The Mercator projection, the most common method of making nautical charts, was developed by a Flemish cartographer in the sixteenth century. The Mercator chart is projected by fast placing a cylinder around the Earth, tangent at the Equator. Planes are passed through the meridians and projected to the cylinder upon which they appear as parallel lines of longitude. Lines are drawn from the center of the Earth to the cylinder passing through the parallels to locate the lines of latitude on the cylinder. Then, the cylinder is cut lengthwise and flattened. See figure 3-10.

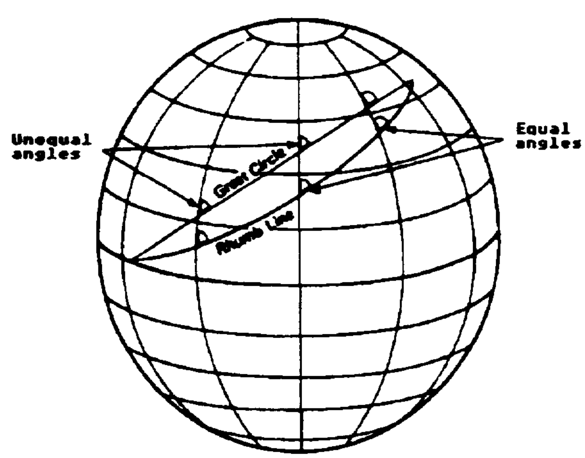

Figure 3-11.—The difference between a great circle and a rhumb line on the Earth's surface.

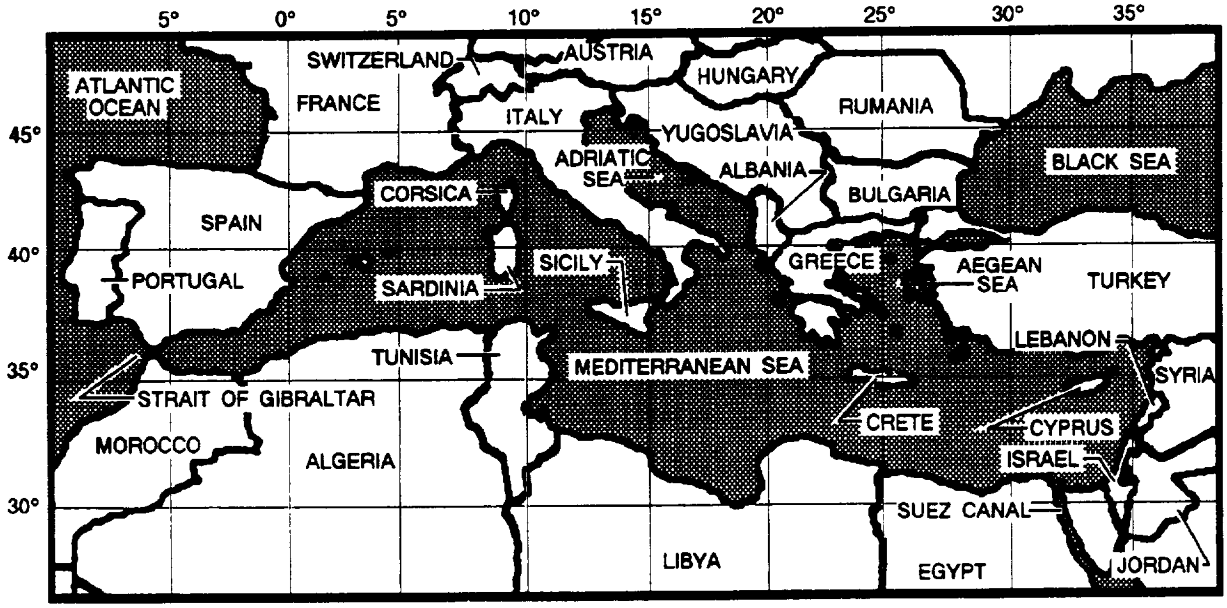

Figure 3-12.—Mediterranean Sea.

The resulting horizontal and vertical lines form a simple Mercator projection. In the production of today's Mercator charts, parallels are spaced by mathematical formulae. The advantage of a Mercator projection is that it is a conformal chart, showing true angles and true distance. A rhumb line (a line that makes the same angle with all intersected meridians) plots as a straight line on a Mercator chart. See figure 3-11. On a Mercator chart, meridians are parallel. A disadvantage of a Mercator chart is the distortion at high latitudes. At the poles, meridians actually converge; however, they are parallel on the chart. Greenland, in the higher latitudes on a Mercator chart, appears larger than the United States, although it is much smaller. Even in the high latitudes though, the distortion on a Mercator projection does not prevent the measurement of true distance.

AREAS OF INTEREST

We will conclude with a brief discussion of some of the more important U.S. Navy operating areas. These include the Mediterranean Sea, the Middle East/Persian Gulf area, and the Western Pacific.

MEDITERRANEAN SEA

The nearly landlocked Mediterranean Sea has been an influential factor in world affairs throughout history. The Navy's Sixth Fleet operates from the Strait of Gibraltar at the western end of the Mediterranean, to the shores of Israel, Lebanon, and Syria at the eastern end. See figure 3-12. The Strait of Gibraltar is a vital choke point between the Mediterranean and the Atlantic Ocean, as is the Suez Canal, which provides access from the Mediterranean to the Red Sea and the Indian Ocean beyond.

MIDDLE EAST/PERSIAN GULF

The U.S. Navy has significantly increased its role in this volatile area. The Commander, Joint Task Force Middle East, located at Bahrain, is augmented by ships of both the Atlantic and Pacific Fleets. Atlantic Fleet ships enter the Red Sea via the Suez Canal and then proceed through the Gulf of Aden to the North

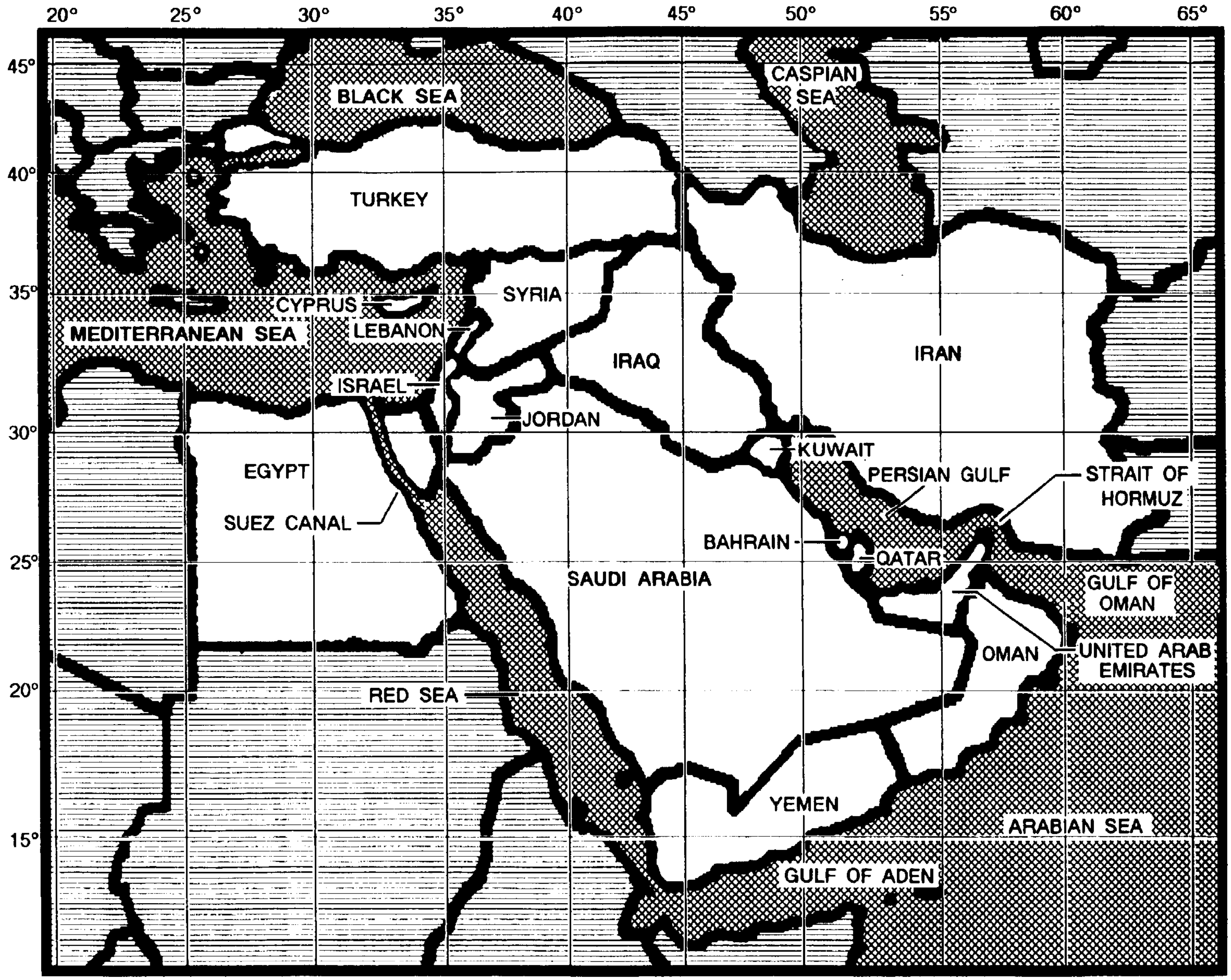

Figure 3-13.—Middle East.

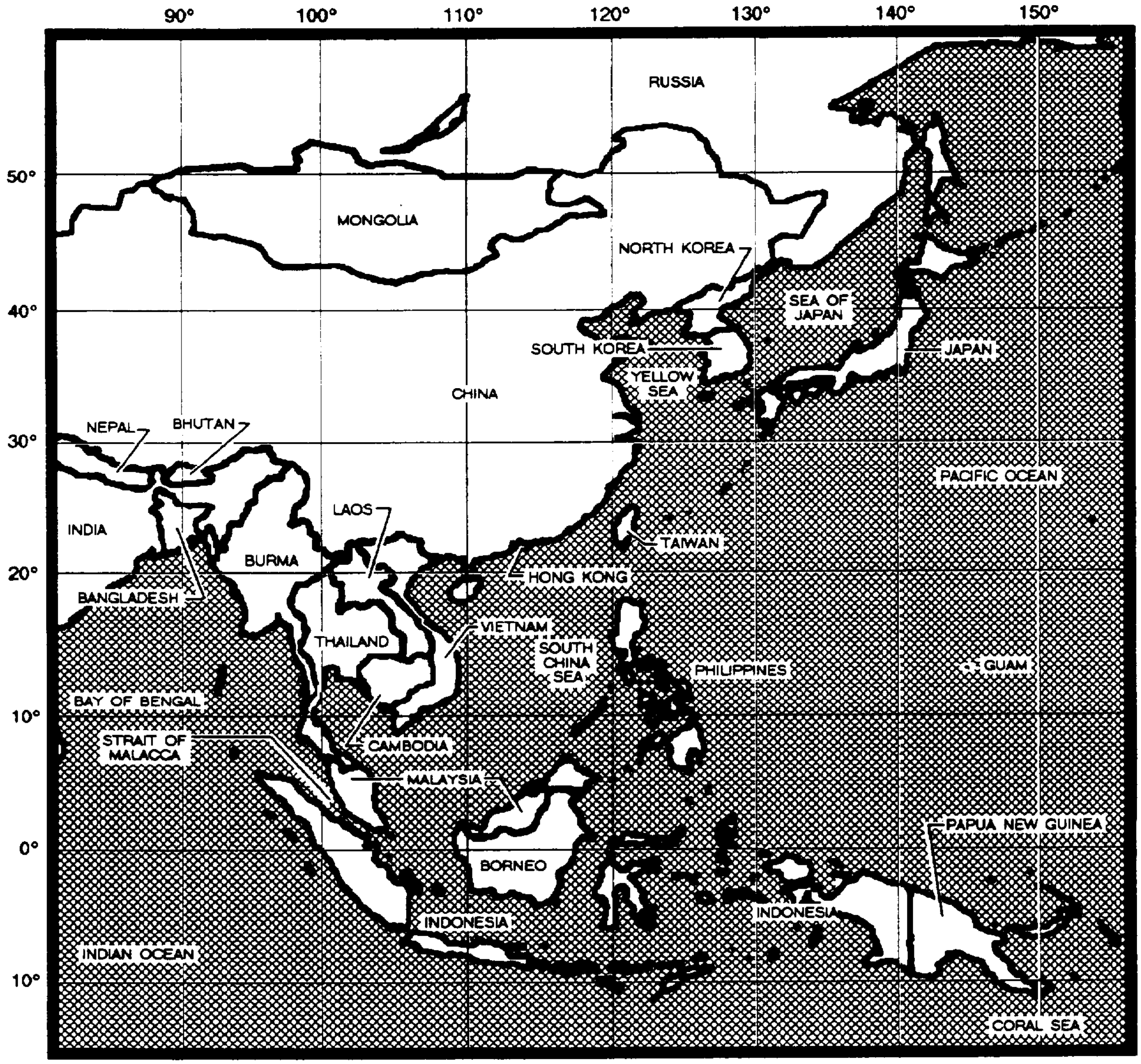

Figure 3-14.—Western Pacific.

Arabian Sea/Gulf of Oman. To enter the Persian Gulf (also referred to as the Arabian Gulf), ships must navigate another strategic choke point, the Strait of Hormuz. See figure 3-13.

WESTERN PACIFIC

The U.S. Seventh Fleet, headquartered in Yokosuka, Japan, is responsible for this large area. See figure 3-14. A carrier battle group is homeported in Yokosuka to quickly respond to any regional tensions. Our naval presence in the Southeast Asia area is changed somewhat now with the loss of our base in Subic Bay, Republic of the Philippines. Many of those support activities have relocated to Guam. Continued presence in the area is important to protect the Strait of Malacca, the passage between the South China

Sea, and the Indian Ocean. Pacific Fleet ships enroute to the Arabian Sea/Persian Gulf transit this strait. It is also an important commercial route. Most of the tankers carrying Mideast oil pass through it on their way to Pacific ports.

REFERENCE

Analysis and Reporting—Analysis Tools, NSGTP 683-14-44-90, Naval Education and Training Program Management Support Activity, Pensacola, Florida, 1990.